# Processing Dermatoscopic Images to Extracting Diagnostic Features Using Morphological Operators and Shape Descriptors

P.Ghassemi[1] , M.H.M.Baygi[2]
[1,2]Department of Biomedical Engineering, Faculty of Engineering, Tarbiat Modares University, Tehran, Iran
Email: p_ghassemi@modares.ac.ir

*Abstract*- **In the European Community melanoma accounts for 1 and 1.8% of cancers occurring in men and women, respectively. The incidence rate is increasing faster than that of any other tumor. The ABCD scheme for early detection of melanoma is commonly accepted. One of the most important sign of malignant melanoma is shape of border that determine very difficult in early stage of disease. In this work we will present how these diagnostic features could be extracted using morphological operators and shape descriptors.**
***Keywords -*** **Morphology, shape descriptor, melanocytic lesion (melanoma), feature extraction**

## I. Introduction

Skin cancer is the most common and most rapidly increasing form of cancer in the world specially united states [1]. Most of the melanocytic lesions are benign and malignant cases are being seen, rarely. Survival rate are reversely related to the tumor thickness. Then diagnosis of the melanoma in early stages is very vital. Physicians are using some outward features of lesion for diagnosing type of it. These features are introduced in some rules which the most famous of them is ABCD-rule. This law is established on features like color, asymmetry, border irregularity and size of lesion [1]. One of the most important sign of malignant melanoma is shape of border that determine very difficult in early stage of disease. In this work we will present how these diagnostic features could be extracted using morphological operators and shape descriptors, in accordance with ABCD-rule[2,3].

## II. Methodology and results

At the first we will review concepts of morphology and after that definition of features will be presented.

### *A. Morphology – basic concepts*

Assume that A and B are subsets of $Z^2$, a=($a_1$,$a_2$) and b=($b_1$,$b_2$). Translation of A with vector X=($x_1$,$x_2$), $(A)_x$ , defines as

$$(A)_x = \{c \mid c = a + x \quad , \qquad for \qquad a \in A\} \tag{1}$$

Reflection of B is

$$\hat{B} = \{x \mid x = -b \quad , \qquad for \qquad b \in B\} \tag{2}$$

Also, complement of A is as

$$A^C = \{x \mid x \notin A\} \tag{3}$$

At least difference between A and B defines as

$$A - B = \{x \mid x \in A, x \notin B\} = A \cap B^C \tag{4}$$

Dilation and erosion are the most important operators that are the basis of most morphological operations. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as dilation or erosion. In dilation the value of the output pixel is the *maximum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1. Dilation A with B " $A \oplus B$ " defines as bellow

$$D(A,B) = A \oplus B = \bigcup_{\beta \in B} (A + \beta) = \{x \mid (\hat{B})_x \cap A \neq \emptyset\} \tag{5}$$

Subset B in dilation and other morphological operations is called structuring element. Differences in size or shape of structuring element are helpful for extracting information form target image. In erosion the value of the output pixel is the *minimum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0. Erosion A with structuring element B can be written as

$$E(A,B) = A \ominus B = \bigcap_{\beta \in B} (A + B) = \{x \mid (B)_x \subseteq A\} \tag{6}$$

Opening and closing are other two morphological operators. Dilation and erosion are often used in combination to implement image processing operations. For example, the definition of a morphological opening of an image is an erosion followed by a dilation, using the same structuring element for both operations. The related operation, morphological closing of an image is the reverse, it consists of a dilation followed by an erosion with the same structuring element. We can use morphological opening to remove small objects from an image while preserving the shape and size of larger objects in the image. Opening of subset A with structuring element B, $A \circ B$ , defines as bellow:

$$A \circ B = (A \ominus B) \oplus B \tag{7}$$

Closing of subset A with structuring element B, defines as bellow:

$$A \bullet B = (A \oplus B) \ominus B \tag{8}$$

HoM transform is an essential operation for detecting a specified object in an image. Eq. 9 shows basic definition of HoM.

$$A \otimes B = (A \oplus X) \cap [A^C \oplus (W - X)] \tag{9}$$

Where X is searching object, W is an arbitrary window including X, $A^c$ is complement of A, and B is combination of X and W-X. Centroid of X will be extracted after HoM transform. Above equation can be written as follow [4]:

$$\begin{aligned} A \otimes B &= (A \oplus B_1) \cap (A^C \oplus B_2) \\ A \otimes B &= (A \oplus B_1) \cap (A \oplus \hat{B}_2) \end{aligned} \tag{10}$$

*B. Feature extraction*

In this work we assume that segmentation process on dermatoscopic images is done. It means that according to some valuable methods data base of color images are mapped to binary pictures. So, we explain all proposed methods of feature extraction on binary maps. All methods will be discussed in two categories: shape descriptors and morphological operators.

*1) Shape descriptors*

In this paper morphological operators are used to extract features of skin lesions such as asymmetry, size, and border's irregularities. We will use roundness, eccentricity, and rectangularity to describe asymmetry of lesion. For evaluation irregularity of border between lesion and surrounding healthy tissue, some parameters such compactness, sphericity, convexity, and solidity are used. Also for measuring the lesion's size we use elongation parameter [5].

A measure of roundness or circularity (area-to-perimeter ratio) which excludes local irregularities can be obtained as the ratio of the area of an object to the area of a circle with the same convex perimeter.

$$Roundness(Circularity) = \frac{4\pi \times Area}{(Convex \quad Perimeter)^2} \tag{11}$$

This statistic equals 1 for a circular object and less than 1 for an object that departs from circularity, except that it is relatively insensitive to irregular boundaries. The convex perimeter of an object is the perimeter of the convex hull that encloses the object. Usually a benign lesion has higher roundness than malignant melanoma "Fig. 1".

Fig. 1. Roundness, benign lesion (right) 0.2611, and malignant melanoma (left) 0.1484

Eccentricity is the ratio of the length of the short (minor) axis to the length of the long (major) axis of an object.

$$Eccentricity(Ellipticity) = \frac{MinorAxisLenght}{MajorAxisLenght} \tag{12}$$

The result is a measure of object eccentricity, given as a value between 0 and 1. Closer values to 1 mean more similarity to ellipse and circle. So, lesions with higher eccentricity, belongs to benign category "Fig. 2".

Fig. 2. Eccentricity, benign lesion (right) 0.8383, and malignant melanoma (left) 0.7422

Rectangularity is the ratio of the object to the area of the minimum bounding rectangle. Let $F_k$ be the ratio of region area and the area of a bounding rectangle, the rectangle having the direction k. The rectangle direction is turned in discrete steps, and rectangularity measured as a maximum of this ratio $F_k$.

$$rectengularity = \frac{Area}{Bounding\ rectengle\ Area} \tag{13}$$

Rectangularity has a value of 1 for perfectly rectangular object. Closer values to 1 mean more similarity to rectangle. So, lesions with higher rectangularity, belongs to benign category "Fig. 3".

Fig. 3. Rectangularity, benign lesion (right) 0.7851, and malignant melanoma (left) 0.6397

Compactness is defined as the ratio of the area of an object to the area of a circle with the same perimeter. This parameter depends to border irregularity and a circle is used as it is the object with the most compact shape.

$$Compactness(Circularity) = \frac{4\pi \times Area}{(Perimeter)^2} \tag{14}$$

The measure takes a maximum value of 1 for a circle. For objects with irregular border (malignant melanoma), this value decrease to zero “Fig. 4”.

Fig. 4. Compactness, benign lesion (right) 0.0888, and malignant melanoma (left) 0.0491

Sphericity measures the degree to which an object approaches the shape of a “sphere”. Sphericity is equal to ratio of radius of inscribing circle to radius of circumscribing circle. These circles must be centered to the centroid of lesion.

$$Sphericity = \frac{R_{inscribing}}{R_{circumscribing}} \tag{15}$$

For a circle, the value is the maximum of 1. So, objects with irregular border have sphericity near to zero “Fig. 5”. So, this parameter could differentiate between benign and malignant melanoma.

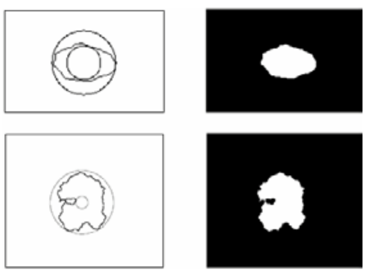

Fig.5 . Sphericity, benign lesion (right) 0.5325, and malignant melanoma (left) 0.1989

Convexity is the relative amount that an object differs from a convex object. A measure of convexity can be obtained by forming the ratio of the perimeter of an object’s convex hull to the perimeter of the object itself.

$$Convexity = \frac{Convex \quad Perimeter}{Perimeter} \tag{16}$$

This will take the value of 1 for a convex object, and will be less than 1 if the object is not convex, such as one having an irregular boundary (like malignant skin lesions) “Fig. 6”.

Fig.6 . Convexity, benign lesion (right) 0.7438, and malignant melanoma (left) 0.6266

Solidity measures the density of an object. A measure of solidity can be obtained as the ratio of the area of an object to the area of a convex hull of the object.

$$Solidity = \frac{Area}{Convex \quad Area} \tag{17}$$

A value of 1 signifies a solid object, and a value less than 1 will signify an object having an irregular boundary, or containing holes “Fig. 7”.

Fig.7 . Solidity, benign lesion (left) 0.9252, and malignant melanoma (right) 0.7750

In its simplest form elongation is the ratio between the length and width of the object bounding box.

$$Elongation = \frac{Width_{bounding-box}}{Lenght_{bounding-box}} \tag{18}$$

The result is a measure of object elongation, given as a value between 0 and 1. If the ratio is equal to 1, the object is roughly square or circularly shaped. As the ratio decreases from 1, the object becomes more elongated. This measure contains information about size and extension of lesion. In this work we use difference of elongation from 1 as a parameter to reach higher value for elongated lesions “Fig. 8”.

Fig.8 . Elongation, benign lesion (right) 0.1285, and malignant melanoma (left) 0.6117

*2) Morphological operators*

Application of morphological operators in this work is to find out irregularity index and convex area of a lesion. Irregularity index determines with use of two useful morphological operations, opening and closing. These two operators apply on binary image of lesion which is created from segmentation procedure. As most of melanocytic lesions are semi-circular objects, we use disk-shaped structuring element. After opening, outer edges of lesion eliminate and after closing inner ones eliminate. So, if we subtract original binary image from these two images, and add the results together, final image contains all pixels of outer and inner irregularities. By dividing number of final pixels with lesion’s area, irregularity-index will be defined.

$$Irregularity\_index = \frac{\hat{A}}{A} \tag{19}$$

$$\hat{A} = \hat{A}_1 + \hat{A}_2$$

So, malignant lesions with irregular border can be determined with this parameter "Fig. 9 and 10".

Fig. 9. Closing (left), opening (middle), and final image (right)

Fig. 10. Irregularity-index, benign lesion (right) 0.0491, and malignant melanoma (left) 0.0888

Also, in this work we use HoM transfer to extract convex area of lesion which is used for calculating of some shape descriptors.

These nine features together with information of lesion color could be used for skin lesion classification.

## III. DISCUSSION

In this study, we demonstrated appropriate methods for extracting diagnostic features according to ABCD rules for the early diagnosis of melanoma. All extracted features are in accordance with a valuable diagnostic rule, and most of them can not be evaluated with physicians' eye. So, with applying proposed automatic processing steps on dermatoscopic images and using an appropriate feature selector and classifier, we can create an intelligent automatic package for detecting malignant melanoma in early stage which couldn't reach with physicians.

## IV. CONCLUSION

As we mentioned, diagnosis of type of melanocytic lesion in early stage is very difficult for physicians because some critical features especially border irregularity can not be seen when lesion is in early stage of appearance. So, proposing computerized methods for detecting lesion's features in accordance with accepted phenomenon could be valuable and decrease mortality of such cancerous lesions. Also, this work could prevent unnecessary biopsies that mostly use with physicians to determine type of lesion.


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## REFERENCES


[1] D.E. Elder, "Skin cancer: Melanoma and other specific nonmelanoma skin cancers," *Cancer Supplement*, vol.75, no.1, pp.245-256, 1994.

[2] K.M. Wolff, and H.D. Pehamberger, "Malignes Melanoma:Fuherkennung und prognose," *Wiener Klinische Wochenschrift*, vol.97, no.10, pp. 451-455, may 1985.

[3] R.P.Braun, L.E.French, H.Saurat, "Dermoscopy of pigmented lesions: a valuable tool in the diagnosis of melanoma". *SWISS MED WKLY,* 2004;134:83-90, Pigmented Skin Lesion Unit, Department of dermatology, University Hospital, Geneva, Switzerland.

[4] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", *Addison-Welsey,* 2004.

[5] "Shape Analysis and Measurement", Biocomputing group, Computing and information science, University of Guelph; 2003.